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A Digital Workbook Tool to Support Asynchronous Collaboration

Final Report

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1. Introduction

From a collaboration point of view, sharing information is one of the most important activities in teaching-learning scenarios. Most of the time students share information without using exchange structures or adequate supporting tools. In that sense, collaborative learning techniques provide strategies to support the student learning process by doing some activities more than simply watching and listening. However, collaborative learning activities are still difficult to design and apply inside the classroom; especially if those activities include new technological elements. In that way, we are interested in the development of technological solutions to be integrated in an educative setting supporting social interactions among different group members. The solutions will allow students to achieve the pedagogical goals in an effective manner, by acquiring abilities like problem solving, critical thinking, meta-cognitive thinking (learning to learn), and information retention, as it was proposed by Johnson & Johnson [1].

Some years ago the authors proposed a Collaborative Evaluation Technique (CET) [2], which involves three stages composing a collaborative examination process: a pre-test, a test and a post-test. The pre-test main goal is to help students to understand and assimilate, in an early stage, the knowledge that is going to be considered in the test phase. The test phase involves the individual resolution of an exam, similar to a traditional examination process, which is face-to-face and hand-written. Finally, the post-test intends to reach two main goals: (1) that students find the right answers to the test questions/items through a discussion among them, and (2) that students identify the right points and the mistakes in their answers. At the end, in an individual manner, each student grades his/her own exam and give it back to the instructor. For the correction of their own exams, the students use the solution outline constructed by the group during the discussion session. Finally, students grade their own exam as a whole, in accordance with the individual grades assigned to each answer of the test. The students’ answers are then examined and graded by the instructor or the teaching assistant. Students that find the right answers during the post-test receive a bonus in their exam final score.

On this context, the authors propose to use a collaborative software tool to support some activities involved in the CET. It will help to reduce the effort involved in performing the CET process. Such tool has been named the Digital Workbook. This solution keeps the traditional paper notebook metaphor in order to allow students to express their ideas and annotations in a natural way. The digital workbook also offers to the users several interaction mechanisms among group members, which can be used to support collaborative activities. In that way, students can build in a collaborative manner, their responses to the problems proposed in the pre-test and post-test stages by using services of the digital workbook, e.g. the creation of work sheets they can share, annotate and publish. Mechanisms such as annotations or publications convey communication elements in synchronous and asynchronous way.

A particular module of this tool, which was named CETProfessor, was implemented to support the instructor during the activity preparation and monitoring processes. This module includes several services, e.g.: (1) a list of questions that can be reused during tests, (2) services to configure access grants for the accounts of users participating in the activity, and (3) various communication services that are useful to publish the questions and responses involved in the activity. Some of these services include: a social diagram, participation records, and registered users list and on-line.
This document presents the achieve activities and results of the project named: "A Digital Workbook Tool to Support Asynchronous Collaboration", supported by LACCIR (Latin American and Caribbean Collaborative ICT Research federation), Grant No. R0308LAC001. This project was executed in collaboration between Universidad de Chile and Universidad del Cauca (Colombia).

1.1 Project Objectives

In this Project we will design, develop and test a software tool based on the digital workbook paradigm, for TablePCs. This tool will allow teachers and students to share different kinds of documents in the context of the CET technique.

1.1.1 Main objective

To develop a framework for shared digital work (a Digital Workbook) based on TabletPCs as a tool to support the CET technique (Collaborative Evaluation Technique).

1.1.2 Specific Objectives

a. To develop a model of shared objects that can be used in collaborative scenarios.
b. To design a framework that supports the distribution of objects in the teaching/learning context defined in CET.
c. To design and develop awareness services as support for the collaboration in the context of the proposed framework.
d. To validate the model and the framework using a real case of study.

1.2 Background

It is important to mention that CET already counts on a collaborative system that automates several of its activities. The tool, named MOCET [6] runs on tablet PCs and PDAs, and utilizes a stylus to keep the metaphor of the paper notebook. This system allows each student to share information just with the instructor. For example, a student can retrieve or submit his/her exam using this service. Data persistency and synchronization are managed by a platform named SOMU (Service-Oriented Mobile Units) [3].

Shared objects, e.g. images, text documents or exams, can be accessed on-demand by members of a mobile work session. These persons communicate among them using a mobile ad-hoc network [7], which forms a distributed system. During pre-test, each student can share his/her resources with other students; however during the test and post-test students can interact just with the instructor. In every stage these persons can do annotations on their private or public resources. If the stage allows them, two or more students can exchange or combine their annotations in order to get a consolidated view of their comments. MOCET separates the object from the annotations done over them. It simplifies the implementation of several services, such as the annotation exchange and synchronization, and also the replication of shared objects.
This tool uses an application programming interface provided by Microsoft OneNote [], to access services for hand-writing on tablet PCs and handheld devices. Although these services are useful, every device running MOCET must include the product OneNote as a supporting service. It limits the possibility to reuse the tool in more than one scenario. In addition, MOCET have shown some usability limitations mainly in the module that allow instructor to prepare and monitor a CET activity. These reasons motivated to the authors to develop a completely new system that solve the already mentioned MOCET limitations.

1.3 Technology exploration

Some of the investigate tools are the following ones:

**Windows Presentation Framework (WPF) and Microsoft Annotations Framework** are part of the .NET framework. We found some problems regarding the low flexibility in the presentation of the information, i.e. all the annotations share the same style. But the main problem was related to the XPS format, which is a format just for visualization and do not permit to modify the content. This feature is inconvenient for a collaborative tool. Figure 1 shows an example of the annotations obtained using these technologies.

![Fig. 1. Example of annotations using Microsoft Annotations Framework.](image)

**Microsoft Office® interoperability libraries:** using some COM libraries it is possible to have access to some functional aspect of tools as Microsoft Word®. The problem regarding these tools is the low options for the graphic aspects.

Other studied tools with similar characteristics are the following ones.

**OneNote:** a Microsoft tool very appropriated for TabletPCs because it facilitates the use of pointers (or pencils) for making hand-writing comments over shared canvas.

**Classroom Presenter:** offers distributed client-server architecture that support TabletPCs clients, based on the interaction into a classroom. It was designed as a presentation tool that support the use of markers and pencils that allow students to make annotations over
the teacher slides. Figure 2 show a sample screen of this tool. This tool can be integrated to the ConferenceXP framework.

![Classroom Presenter interface](image)

**Fig. 2.** Interface of the *Classroom Presenter* tool

Finally, and according to the characteristics and limitations of the studied tools, we decide to use Microsoft Windows XP Tablet PC Edition Software Development Kit 1.7. This is a set of libraries that offer some objects to manipulate the graphics features of the TabletPCs. We also used *Windows Communication Foundation*, which is a library of .NET framework that allows to create service-oriented applications.

## 2. Architecture of the Digital Workbook

The digital workbook was also designed to be used on a Tablet PC; however it does not require any plug-in or software product to provide the services to students and instructors. The tool implements a public and a private space to manage the resources in each computing device. It also implements two communication services: ICET and IPageShare. ICET represents the design contract between CETProfesor (module used by the instructor) and digital workbook (module used by the students) in order to obtain information about proposed questions and group information. IPageShare allows sharing pages between several digital workbooks.

Such service is executed in an autonomous way, and allows students to perform distributed presentation or share information (e.g. pages of the workbook) as part of a private session. Fig 3 shows a general diagram that allows understand how the tool works.
The module CETProfessor manages a database of questions and users. This information and also the exams can be shared with the students using the ICET communication service. Each digital workbook manages its own pages (or working sheets) that could be published or shared according to the participants needs.

2.1 Digital Workbook User Interface

Figure 4 presents a screenshot of the digital workbook main user interface. The interface involves five components or interface areas:

(a) A list of questions given by CETProfessor. Each question has its own responses, describing the communication process.
(b) A list of users that are part of the work group. It uses green color for the connected users and white for the disconnected ones.
(c) A working area. There it is possible to add lines and some graphical components like geometric figures, images and text. Notes or annotations are a special type of components allowing students to make some comments about the content of certain task. Based on these annotations a social diagram is displayed about the interaction of the students.
(d) A menu bar with different components could be integrated and also the communication services that allow sharing page, working sheets or students’ options that can be sent to the instructor.
(e) An information line that allows accessing to the awareness management tool, which was proposed in [5]. In order to obtain awareness independence, the digital workbook and CETProfessor modules implement their own awareness mechanisms. This aspect is going to be evaluated in future experimentations.
2.2 CETProfessor

This module is used just by instructors and it allows: 1) managing the list of questions and users; 2) executing communication services that allow users access shared information, and publish students’ contributions through pages or working sheets; and 3) facilitating tutor mechanisms to monitor a CET activity.

Fig. 5 presents a screenshot of the CETProfessor user interface. In N) we can observe an example of how different users have made some comments to the working sheets of the teammates. In B) it is possible to observe the list of users registered per activity, their connection states and the different responses published in every working sheet. If the user clicks a question in L), the module displays the responses. In M) we can observe the buttons to access the edition window, the questions and the commands to launch and stop the ICET service.
The CETProfessor module does not include functionality to edit the responses in the students working sheets. If the instructor wants intervene, s/he must send a message to the students. In future versions we hope to include mechanisms that allow tutor to intervene in a direct manner over the responses working sheets. Next we describe the experimentation process performed to evaluate this tool.

2.3 Detailed Use case diagrams

Figure 6 presents the general use case diagram for the Digital Workbook tool.

- **Begin session (Iniciar Sesión)**: allows the student to register in the examination service.
- **To open a sheet (Abrir Hoja)**: allows adding a new sheet in the workbook. Figure 7 shows an example of this case of use.
**Fig. 7** “To add a sheet” case of use sample

- **To edit a sheet (Editar Hoja)**: allows editing the content of a specific sheet (see Figure 8).

**Fig. 8** “To edit a sheet” case of use

- **Making annotations (Hacer Anotaciones)**: allows adding annotations to the content of a specific sheet (see Figure 9).
• **Answering questions (Responder Pregunta):** creates a sheet with a response to a particular question given by the teacher (see Figure 10).

• **Publishing a response (Subir Respuesta):** Publish (or submit) a response to a given question. The response is automatically sent to the teacher (see Figure 11).
Fig. 11 “Publishing a response” case of use

- **To annotate responses (Anotar respuesta):** allows to annotate the response sheet created by other student (see figure 12).

Fig. 12 “To annotate responses” case of use

- **Sharing sheets (Compartir Hoja):** allows the necessary mechanisms in order to share sheets.

- **Access to a shared sheet (Acceder a Hoja compartida):** allows accessing the sheets shared by other students (see Figure 13).
**Synchronizing sheets (Sincronizar Hoja):** automatically refresh the content of a shared sheet.

**To see other students (Ver Compañeros de grupo):** Allows accessing the list of students that are part of the group. The students in the list can appear on-line or disconnected (see Figure 14).

**Sending messages (Enviar Mensaje):** allows sending messages to other partners using a simple chat tool.
Figure 15 presents the use case diagram for the CETProfessor tool.

- **To begin services (Iniciar Servicio):** initiates the communication services in the system.

- **To manage the questions (Gestionar Preguntas):** gives the professor the required functionality in order to create, edit and erase the questions of the exams (see Figure 16).

- **To manage work groups (Gestionar grupos de trabajo):** provide the teacher a tool in order to create, edit and erase students and work groups (see Figure 17).
Fig. 17 “To manage work groups” case of use

- **To manage solutions (Gestionar Soluciones):** allows maintaining the responses to the questions given by the students (see Figure 18, right up side corner).

Fig. 18 “To manage solutions” case of use

- **Monitoring activities (Monitorear Actividad):** Represent a set of services in order to monitor and control the collaborative activity. Some of these services are the following ones.
  
  o **To see the social diagram (Ver Sociograma):** shows a social diagram with the relations detected in the annotations on the work sheets (see Figure 19).
"To see the social diagram" case of use

- **Seeing active users (Ver Usuarios Activos):** shows the list of students registered in the system and their connection status.

- **Seeing participation tables (Ver Tablas de Participación):** shows statistics regarding the participation (number of annotations) of every student.

- **Sending messages (Enviar Mensajes):** allows the professor to send messages to the groups.

- **Seeing annotations (Ver Anotaciones):** allows the professor to see the annotations created by the students.

- **Seeing the solutions (Ver Soluciones):** allows the professor to see the responses submitted by the students.

### 2.4 Class diagram

Figure 20 presents the main classes related to the CETProfessor tool.
Figure 20 shows the class diagram for the CETProfessor tool.

Figure 21 shows the class diagram of the Digital Book tool.
The Figure 22 shows the classes hierarchy. A work sheet can have several geometrics figures, as ellipses, rectangles, text, images, and annotations.

![Class hierarchy related to the Shape figure](image)

**Fig. 22** Class hierarchy related to the Shape figure

Figure 23 shows the structure of the Annotation class, which is a special type of figure.

![Structure of the Annotation class](image)

**Fig. 23** Structure of the Annotation class

### 2.5 Package diagram

Figure 24 shows the package diagram that shows the relationships between the different components of the Digital Workbook and CETProfessor tools.
2.6 Deployment diagram

Finally, Figure 25 shows the deployment diagram of the system. Two types of nodes can be observed: Professor and Student. Besides, there are two different communication channels that use WebServices: the first one is used to distribute the questions, responses and messages, and the second one is used to share the work sheets among students.

3. Experimentation

During the experimentation phase we worked with students of a Human-Computer Interaction course in the Computer Science Program at University A (Colombia). The topic
evaluated was user interfaces in collaborative systems; particularly: awareness mechanisms in CSCW environments, usability and tangible interfaces. A set of questions were formulated to support the learning of these topics. We worked with 21 students divided into working groups composed of three randomly selected students. Due to lack of Tablet PCs only two of these groups worked with the digital workbook (ULD), and the other ones (UT) without digital workbooks. In this experiment three tabletPC were used, the ULD groups had to interchange the tabletPCs during the activities. In one of these tabletPC, both Digital Workbook and CETProfesor were executed, in the others, only the Digital Workbook was executed.

3.1 Methodology

The process began with an introductory talk about the topic, where concepts like collaborative work and collaborative learning were explained. The working groups were organized and every student was responsible to acquire the knowledge related to a certain topic (awareness mechanisms in CSCW environments, usability and tangible interfaces). Each student studied in an individual manner the assigned topic and s/he proposed a brief summary that is going to be worked in the activity. Next section explains how do the different activities that conform CET were performed during the experimentation process.

3.2 The process phases

During the pre-test stage the following activities were performed:

Definition of a coordinator (5 min): Each group selected a coordinator, who has the responsibility to promote and solve discussions, and also to coordinate the activity in a way that permit to achieve the group goal in an efficient manner.

Resolution of questions in an individual way (15 min): Based on the preliminary research, every student gave an answer to questions of every topic. UT groups did the work using paper sheets, while ULD groups used the Digital Workbook.

Experts Meeting (15 min): Students from different working groups, that have the same question to answer, were organized by pairs in order to discuss every question and response (Fig. 26 and 27). Changes or updates to their responses are saved as a new version of the answer.

Group meeting (15 min): Once the experts meeting has finished, working groups meet and discuss the responses to the assigned questions. Any change is saved as another version of the response. All documents are sent to the instructor; the ULD groups do not need to do that, because the tool provides such service automatically.
During the test stage we applied a traditional test (see Figure 28), where one of pre-test question was included. We did not use any technological application to support this stage. During the post-test the working groups were organized in order to analyze their responses, including some annotations and notes if they needed. The post-test was evaluated like an additional bonus that was added to the average between pre-test and test. The activity finished when students graded the exam as a whole.

After that, students participated in a discussion about the topics worked and they talked about the experience of this collaborative practice. At the end, they did an exercise that consisted in an essay about the formulation of awareness mechanisms in tangible interfaces, in order analyze if students really understood the topics. Although this phase is not considered as a part of CET, we think adequate to perform this activity to analyze if there was an appropriation of the concepts worked in the CET activity. Finally, we did an interview to the students and they also fill a survey about the experience.
3.3 Obtained results

Table 1 depicts the results obtained during the experience. Groups A, B, C, D, and E were working without digital workbook. However groups F and G were working with the digital workbook. At the end of each phase the students presented a document with responses to the proposed questions. According to these results we can observe all groups improved their scores after pre-test. This could imply the CET is a mechanism that permits to support teaching-learning processes in an independent way, if it is mediated by a computer. Although all groups improved their results comparing grades from pre-test to test, those who were working with Tablet PC got a better performance (their grades improved from 3.5 to 4.37 and from 3.8 to 4.4 into a scale from 1 to 5). More important is the level of improvement obtained by the groups using the digital workbook, which was between 0.6 and 0.9 points.

Table 1. Experimental Results

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Test</th>
<th>Bond Post-test</th>
<th>Final CET</th>
<th>Final Document</th>
<th>Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – UT</td>
<td>4.00</td>
<td>4.10</td>
<td>+0.10</td>
<td>4.20</td>
<td>4.1</td>
<td>4.15</td>
</tr>
<tr>
<td>B – UT</td>
<td>4.27</td>
<td>4.43</td>
<td>+0.05</td>
<td>4.48</td>
<td>4.4</td>
<td>4.44</td>
</tr>
<tr>
<td>C – UT</td>
<td>4.23</td>
<td>4.23</td>
<td>+0.10</td>
<td>4.33</td>
<td>4.6</td>
<td>4.46</td>
</tr>
<tr>
<td>D – UT</td>
<td>3.90</td>
<td>4.07</td>
<td>+0.05</td>
<td>4.12</td>
<td>4.3</td>
<td>4.21</td>
</tr>
<tr>
<td>E – UT</td>
<td>4.3</td>
<td>4.33</td>
<td>+0.15</td>
<td>4.48</td>
<td>4.5</td>
<td>4.49</td>
</tr>
<tr>
<td>F – ULD</td>
<td>3.50</td>
<td>4.37</td>
<td>+0.10</td>
<td>4.47</td>
<td>4.5</td>
<td>4.48</td>
</tr>
<tr>
<td>G – ULD</td>
<td>3.80</td>
<td>4.40</td>
<td>+0.10</td>
<td>4.50</td>
<td>4.6</td>
<td>4.55</td>
</tr>
</tbody>
</table>

It is clear that in CSCL scenarios technology is not the only variable that could influence an improvement of the students' performance. It is necessary to structure the collaborative activities convey a real collaboration. In our experience CET has shown to be a good technique that helps improve teaching-learning process and the use of supporting
technology helps to perform the activity in a better way. The results we obtained were based on quantitative date of the results of the test, for future experimentations we are going to include qualitative aspects like some survey about the experience of the technique and software tool. During these experimentations we have not included the comments of the teacher about the experience. We hope to include experience of the teachers using the Model and software tool we have developed for further work.

Figure 29 presents the media values for every group in the performance of the activity. Groups G and H obtain similar values using the tool. However, when they work without using the tool the performance was low.

![Fig. 29. Performances of the experimental groups](image)

4. Conclusions and future work

This report presented a mobile collaborative application, named digital workbook, which supports activities involved in the collaborative evaluation technique (CET). The metaphor embedded in the digital workbook seems to be appropriate to perform the CET activities. This result can be observed through positive impact the tool had not only to support the experience but also the learning goals.

The modular architecture implemented in the digital workbook allows extending this tool in several ways, by taking advantage of the new TabletPCs capabilities. However it is evident there is a need to establish design guidelines to mitigate the usability problems that still have the technologies for hand-writing on a Tablet PC.

The digital workbook can also be used to support other collaborative learning activities, because it is possible to use its services in an autonomous way and independently of any other component. The monitoring capability of the tool can also be used to support other collaboration activities. Although the obtained results are still preliminary, the use of the tool has shown to be consistently attractive and useful for students and instructors. The
next steps in this work involve more experimentation instances that allow understand the real impact of this proposal including the evaluation of the CETProfessor in order to determine how awareness aspects we have includes could support instructor in the teaching-learning process.

5. References

APPENDIX A

Publications

Journals:


Book chapters:


International Conferences:


**Undergraduate thesis:**


**Master degree thesis:**